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Characteristics of catfish oil, red palm oil and shark liver oil as functional foods

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ABSTRACT

Functional food is a food ingredient in addition to basic needs as nutrients that can also play a functional role in health. This research aimed to determine the physicochemical characteristics and fatty acid composition of catfish oil, red palm oil, and shark liver oil as functional food ingredients. The research method was to extract fish oil from belly flap, purify catfish oil, and process red palm oil (RPO) from crude palm oil (CPO). The analysis parameters consisted of sensory analysis, oil chemical characteristics (free fatty acid analysis, peroxide, iodine, saponification, and acid numbers), total carotene, tocopherol, and analysis of fatty acid composition. The results showed that the catfish oil after being purified had sensory characteristics, smelled slightly fishy and semi-solid, and had a bright yellow color. The results of the analysis of chemical characteristics showed that the free fatty acid numbers of catfish oil and shark liver oil were following IFOS standards (1.33 and 0.62%), and the RPO numbers for peroxide and free fatty acids according to the SNI standards (9.56 meq/kg and 1.44%). The highest ω -3 and ω -6 fatty acids were in shark liver oil (3.56 and 35.35%), followed by catfish oil (1.72 and 19.9%), and RPO does not contain ω -3 and ω -6. Catfish oil, RPO, and shark liver oil act as functional foods. The fatty acid composition of catfish, shark liver and red palm oil contains saturated and the fatty acid composition of catfish, shark liver and red palm oil contains saturated and unsaturated fatty acids. Mono and poly unsaturated fatty acid (FUFA and MUFA) in crude catfish oil, pure catfish oil, shark liver oil, and red palm oils were 56.71, 58.12, 63.81 and 47.39% respectively. The result of analysis showed composition of in catfish oil 1.72 and 19.9%. The content of and of shark liver oil was 3.5 and 35.5%. Whereas in red palm oil does not Ω 3 and Ω 6. The content of EPA and DHA in shark liver oil was 0.08, 0.09 but not in catfish and red palm oil. The total content of carotene and tocopherol in red palm oil was 513.86 and 925.80 mg/kg, respectively. The nutritional composition of catfish oil, red palm oil, and shark liver oil has the potential to be used as functional food.

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Introduction

Catfish (*Pangasius hypophthalmus*) is one of the main commodities of aquaculture in Riau Province. Kampar Regency is the largest freshwater fishery production producer in Riau Province, one of which is catfish. The production of catfish in the Kampar Regency area in 2013-2017 reached 23,185,714 tons (DJKP, 2018). The treatment process is generated by-products consisting of head, skin, bone, stomach fat, offal, and trimming as much as 55% (Sathivel et al., 2003). This by-product is usually processed into fish meal for feed and raw material for fish oil which

has the potential to be developed into food products that have a function as a functional food.

Functional food is food that contains active components that can provide health benefits, beyond the benefits provided as nutrients (Astawan, 2011). Fish as a functional food ingredient has many advantages over other animal products, such as in terms of abundance, lower prices, easy digestibility, and contains unsaturated fatty acids, including Docosahexaenoic acid (DHA), Eicosapentaenoic acid (EPA), and Arachidonic acid (ARA), the mineral content is more complete (Winarti, 2010).

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Fish and fish products are very important for the diet and can be classified as food with functional properties. Fish are a vital food because of their nutritive values and the beneficial impact they have on human health. Fish and fish products contain proteins that are rich in essential amino acids. In addition, fish contain fats that are valuable sources of energy, and fat-soluble vitamins. The most important contribution from fish are their polyunsaturated fatty acids, particularly those from the omega-3 family. These acids display a number of qualities connected with the improvement of human bodily functions and the reduction in susceptibility to cardiovascular diseases and cancer. (Fernandez and Venkatrammann, 1993; Ismail, 2005)

Among the fatty acids in fish are DHA and EPA. EPA and DHA are omega-3 family acids. In fact, fish fats are the basic source of these acids in the human diet, although nuts and some vegetable oils contain considerable amounts of another omega-3 family acid: α -linolenic acid (ALA). PUFAs also include omega-6 family acids.

Research on the by-products of processing catfish as a source of fish oil has been widely conducted. Hastarini *et al.* (2012) showed that the by-product extraction of catfish fillet processing contains 33.95% palmitic acid and 35.85% oleic acid, with a polyunsaturated fatty acid (PUFA) composition of 12.35%, in the form of linoleic fatty acid, linolenic fatty acids, EPA and DHA. According to Ayu *et al.* (2019), stated that fish oil as a by-product of catfish smoke in belly flap contains 26.22% palmitate, 40.14% oleic fatty acids, with a PUFA composition of 23.60% in the form of linolenic fatty acid, linoleic fatty acids, EPA and DHA. The results of this study indicate that catfish oil can be used as functional food such as the prevention of coronary heart disease and as a food ingredient.

Several studies have shown that consumption of PUFAs can reduce the potential risk of cardiovascular disease including plasma cholesterol, triacylglycerols (TAG), inflammatory cytokines, chemoattractants, cell adhesion molecules, eicosanoids, blood pressure, and reduce the risk of death in people with cardiovascular disease (Mozaffarian *et al.*, 2006). Catfish oil is high in ω -6 and ω -9, but low in ω -3 (Thammapat *et al.*, 2010).

Increasing the ω -3 content in catfish oil, it is necessary to add other functional ingredients that are high in ω -3 content. Many sources of ω -3 are found in marine fish, one of which is the liver of shark (*Centrophorus atromarginatus*). Shark liver is a source of raw material for fish oil because it is rich in ω -3. The ω -3 fatty acids are very important for health among

other fatty acids because they have anti-inflammatory and anti-clotting effects, are also good for the brain, central nervous system, and can prevent cardiovascular disease (CVD) (Diana, 2013).

Catfish oil does not contain β -carotene as a provitamin A which functions as a precursor to vitamin A production in the body (Ayu *et al.*, 2019). The addition of β -carotene to catfish oil is needed as another functional ingredient, namely red palm oil. Red palm oil has the potential as a functional food ingredient because of β -carotene content and other functional components. β -carotene is a provitamin A carotenoid with the highest activity for each molecule of β -carotene can produce two molecules of retinal which is then reduced to retinol (Vitamin A) (Fernandes-Garcia *et al.*, 2012).

Red palm oil is a product of processed vegetable ingredients from crude palm oil (CPO) to maintain carotenoid content, especially β -carotene which has very high provitamin A activity. The beta carotene content in red palm oil is 316.94 μ g/g. Red palm oil is a product of processed vegetable ingredients from crude palm oil (CPO) to maintain carotenoid content, especially β -carotene which has very high provitamin A activity. The beta carotene content in red palm oil is 316.94 μ g / g. Red palm oil is also a source of vitamin E. Vitamin E contains tocotrienol and α -tocopherol which have been shown to slow down the aging process (Song, 2006).

The main carotenoids contained in RPO are α - and β -carotene, which act as provitamin A (Lee *et al.*, 2018) and are 15-30 times higher than carrot and tomato. Besides, carotenoids, tocopherols, and tocotrienols, also have antioxidant effects that act as protection against health problems mediated by reactive oxygen, such as cancer, cardiovascular, neurological, and eye diseases (Sathasivam *et al.*, 2018). The minor component also functions as a natural antioxidant (Neo *et al.*, 2010), which can reduce oxidative stress and function to prevent or delay some chronic degenerative diseases (Ayustaningwarno, 2012).

Carotenoids are a group of yellow retinol values (Choo *et al.*, 2003). Thus, carotene can also be used to overcome the problem of lack of vitamin A, namely as a natural dye and food supplements that are very beneficial for improving health (Rice and Burns, 2010; Manorama, 2014). Red palm olein (RPO) has been used in various forms of food products as a source of carotene (pro-vitamin A) for children who are deficient in vitamin A (El-Hadad *et al.*, 2011).

Vitamin E plays a role in the body's protection against diseases that are mediated by free radicals and

for the prevention of heart attacks (Al-Sager et al., 2004). Vitamin E is present in eight isomeric forms, namely four tocopherols and four tocotrienols. Tocotrienol is much better as an antioxidant (Musa et al., 2017) than tocopherol. Palm tocotrienol has blood cholesterol-lowering properties and inhibits cancer cell growth (El-Hadad et al., 2011). However further investigation is needed to assess the impact of increasing the proportion of linoleic acid (Omega 6) in RPO do to intentional reduction of saturated for human health.

been shown to slow down the aging process (Song, 2006). Based on the results of previous studies, it is necessary to conduct further research on the characteristics of catfish oil, red palm oil and shark liver oil as food ingredients. This study was to determine the physicochemical characteristics and fatty acid composition of catfish oil, red palm oil, shark liver oil and the potential to be used as functional food. Oil and could potentially be used as a functional food

Materials and Methods

Materials and tools

The main ingredients used in the study were by-products from the catfish smoking industry in XIII Koto Kampar District, Kampar Regency, Red Palm Oil, CPO processing from PKS Sei Galuh at PT Perkebunan Nusantara V, which was refined at the Palm Oil Processing Engineering Laboratory at Kampar Polytechnic, and Commercial shark liver oil was purchased from a Herbal Shop in Surakarta, Central Java. The chemicals consist of absorbance (bentonite and activated charcoal), aquades, ethanol (Merck, p.a), phenolplatein indicator, KOH (Merck, pa), 0.1 N, KOH 0.5 N, HCl (Merck, p.a) 0.5 N, glacial acetic acid (Merck, p.a) Chloroform (Merck, p.a) KI 15%, amilum, Na₂S₂O₃, 1-butanol (merck, p.a), Iodine bromide (merck, p.a), toluene (Merck, p.a), bipyridine (Merck, p.a), FeCl₃.6H₂O (merck, p.a), methanol (Merck, p.a), sodium methanolate, anhydrous (Merck, p.a) Na₂SO₄ (Merck, p.a) and n-hexane (Merck, p.a).

The tools used in this study are aluminum foil, stopwatches, digital scales, burettes, glassware, electric stoves, centrifuges, micro pipettes, spectrophotometer (Optima SP-300) and Gas Chromatography Spectrometry (GC) (SHIMADZU, Jepang) and other applications

Research methods

The research method used a laboratory experiment method by extracting catfish oil from belly flap, as well as processing smoked catfish using the dry rendering method, resulting in crude oil.

Crude oil was purified using bentonite absorbent and activated charcoal to produce pure catfish oil. Red palm oil was made from CPO from PTPN Sei. Galuh. The red palm oil processing process was carried out at Politeknik Kampar. The analysis parameters consisted of the physicochemical properties of catfish oil, red palm oil, and shark liver oil consisting of sensory analysis, oil chemical properties (free fatty acid numbers, iodine, peroxide, lathering) specifically for red palm oil, carotene and tocopherol analysis.

This research was designed to consist of 2 stages, stage 1. Extraction of catfish oil. Stage 2. Refining of catfish oil and characterization of physicochemical properties of catfish oil, shark liver oil and red palm oil.

Extraction of catfish oil

Oil extraction refers to Damongilala (2008), the extraction was carried out by a dry rendering system using an oven. Catfish belly flap was homogenized using a blender, then put in an oven that using an electric system via a temperature control element, then heated at 70°C for 8 hours. The oil was collected in a container and centrifuged to separate the impurities. The extraction result in the form of crude catfish oil then stored in a dark bottle.

Crude catfish oil was characterized by its chemical properties with parameters: free fatty acid content, acid number, peroxide number, iodine number and saponification number.

Catfish oil purification

Crude catfish oil was placed in a container and heated until the temperature of 60°C. Then, bentonite adsorbent and activated charcoal was added with a ratio of 3:2 as much as 5% from the weight of the oil to be refined. The purification process was continued until the temperature of 70°C, for 30 minutes. Furthermore, the oil was centrifuged. The pure catfish oil was then stored in a dark bottle at -18°C until it was used for the next step.

Analysis procedure

Analysis of fatty acid profiles using gas chromatography (AOAC, 2005)

The analytical method used the principle of converting fatty acids into their derivatives, namely methyl esters, so that they were detected by chromatography. The analysis results were shown through several peaks at a certain retention time according to the character of each fatty acid and compared with the standard. The fat was extracted from the material first before injection of the methyl ester then the methylation was carried out so that the methyl ester was formed from each of the fatty acids obtained.

a. Methyl ester formation

The fatty acids were converted to other methyl or alkyl esters before being injected into gas chromatography. Methylation was carried out by refluxing the fat on a water bath with 0.5 N, BF_3 and n-hexane, respectively. A total of 0.02 g of oil from the sample was put into a test tube and added with 5 mL of 0.5 N NaOH-methanol then heated in a water bath for 20 minutes at 80°C then cooled. 5 mL of BF_3 was added to the tube then heated again using a water bath with a temperature of 80°C for 20 minutes and then cooled. Add 2 mL of saturated NaCl and shake it, then add 5 mL of hexane, then shake it. The hexane solution at the top is transferred with the help of a dropper into a test tube. 1 μL of the fat sample was injected into gas chromatography. Fatty acids were identified by a flame ionization detector (FID) or flame ionization detector, the response was being recorded through a chromatogram (peak).

b. Fatty acid identification

The identification of fatty acids was carried out by injecting methyl esters into the Shimadzu GC 2010 Plus gas chromatograph. The gas used as the mobile phase is nitrogen gas with a flow rate of 30 mL / minute and the combustion gas is hydrogen and oxygen. The column used is a Quadrex capillary column with an inner diameter of 0.25 mm.

- Column: Cyanopropyl methyl sil (capillary column)
- Column dimensions: P = 60 m, $\varnothing$ in = 0.25 mm, 0.25 μm film thickness
- Flow rate of N_2 : 30 mL / minute
- H_2 flow rate: 40 mL / minute
- Air flow rate: 400 mL / minute
- Injector temperature: 220°C
- Detector temperature: 240°C
- Inject volume: 1 μL

Free fatty acid (% ffa) (AOAC, 2005)

A total of 2.5 g of oil plus 25 mL of 95% alcohol (Erlenmeyer 200 mL), heated in a water bath for 10 minutes, then drop 2 drops of the PP indicator on the mixture. After that the mixture was shaken and titrated with 0.1 N KOH until a pink color appeared that did not disappear in 10 seconds. The FFA percentage, acid number and degree of acidity are calculated based on the following equation:

$$\% \text{ FFA} = (A \times N \times M) / (10 G) \dots\dots\dots(1)$$

$$\text{Acid number} = (A \times N \times 56.1) / G \dots\dots\dots(2)$$

$$\text{Degree of acidity} = (A \times N \times 100) / G \dots\dots\dots(3)$$

where: A: Number of KOH titrations (mL); N: Normality of KOH; G: Sample weight (g); M: The molecular weight of the dominant fatty acid (oleic acid: 282.5)

Peroxide Number (PV) (AOAC, 2005)

The method of determining the peroxide number used the principle of titration of iodine which was released from the potassium iodide compound by peroxide using standard thiosulfate solution as the titrant and starch solution as an indicator. This method detects all substances that oxidize potassium iodide under acidic conditions. A total of 2.5 g of sample was put in a 250 mL Erlenmeyer flask, plus 30 mL of acetic acid and chloroform solution in a ratio of 3:2, then added with 0.5 mL of potassium iodide (KI) solution, the solution was then shaken carefully, then added 30 mL of distilled water. Furthermore, the solution was titrated with 0.01 N sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$) until it turns yellow, after which 0.5 mL of 1% starch indicator solution was added which will change the color of the solution to blue. The titration was then continued simultaneously by continuing to shake the solution until it changes color to light blue which indicates the release of iodine from the chloroform layer. Titration is continued carefully until the blue color of the solution was gone. The calculation of the peroxide value was carried out with the following equation:

$$\text{Peroxide number} = (S \times M \times 1000) / G \dots\dots\dots(4)$$

where: S: Total sodium thiosulfate (mL); M: Concentration of sodium thiosulfate (0.01 N); G: Sample weight (g).

Iod numbers (AOAC, 2005)

A sample of 0.5 grams was put in a closed erlenmeyer, then added 10 ml of chloroform and 25 mL of iodine-bromide reagent and let stand for 30 minutes in a dark room while shaking it. Furthermore, 10 mL of 15% KI were added and diluted with 100 ml of distilled water. Titration was carried out with sodiumthiosulfate ($\text{Na}_2\text{S}_2\text{O}_3$) 0.1 N until the color turned light yellow, then added 3 drops of starch indicator then titrated again until the blue color disappeared.

$$\text{Iod number} = (B-A) \times N \times 12,691 / G \dots\dots\dots(6)$$

Where: A: sample titrant (mL); B: blank titrant (mL); N: Normality of $\text{Na}_2\text{S}_2\text{O}_3$; G: sample weight (g).

Saponification numbers (AOAC, 2005)

A total of 5 grams of fish oil was put into a 250 ml erlenmeyer and added 50 ml of KOH which was made from 40 grams of KOH in 1 liter of alcohol. The mixture is boiled for 30 minutes and phenophtalin indicator was added and titrated with 0.5 N HCl.

$$\text{Saponification number} = 28.05 \times (B-A) / G \dots\dots\dots(7)$$

Where: A: sample titrant (mL); B: blank titrant (mL); G: sample weight (gr).

B-carotene levels (PORIM, 2005)

The sample was dissolved as much as 0.04 g of hexane mixture into a 10 mL volumetric flask until the mark was reached, then shaken until completely homogeneous. Then the absorbance was measured using a spectrophotometer at a wavelength of 446 nm. The β -carotene content is calculated using the following formula:

$$\text{Carotene content} = \frac{25 \times \text{absorbance} \times 383}{100 \times \text{sample weight (g)}} \dots\dots\dots (8)$$

Total tocopherol content (Wong *et al.*, 1998)

The total sample tocopherol was measured based on research by Wong *et al.*, (1998). The sample was put in 0.1 g into a 10 mL measuring flask, then added 5 mL of toluene, 2.2 bipyridine (0.7% w/w in 95% ethanol) 3.5 mL, and FeCl₃ · 6H₂O (0.2% w/v in 95% ethanol) 0.5 mL. The solution was adjusted to 10 mL with 95% ethanol, then vortexed and let stand for 10 minutes. The absorbance was measured using a spectrophotometer at a wavelength of 520 nm with a blank made the same way without a sample. The total tocopherol concentration was calculated based on the α -tocopherol standard curve in the range of 100-1500 ppm.

Data analysis

The data obtained were analyzed based on equations and were analyzed descriptively in a comprehensive manner with the appropriate. The data from the analysis results were presented in the form of tables, schemes, pictures and conclusions were drawn from the results of the analysis.

Results

The results of the study of the physical characteristics of crude and pure catfish oil can be seen in Figure 1 and the chemical characteristics of catfish oil, shark liver oil, and red palm oil can be seen in Table 1. The results of the analysis of the fatty acid profiles of catfish oil (crude and refined), red palm oil, and shark liver are presented in Table 2.

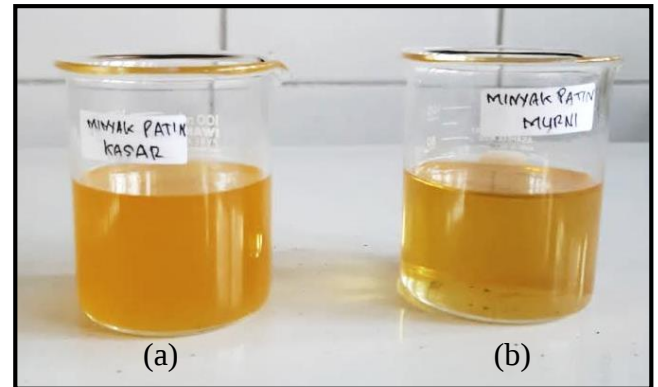


Figure 1. Catfish oil (a) crude oil, (b) refined oil.

Discussion

Characteristic of physicochemical catfish oil

Catfish crude oil from the extraction of catfish belly fat has a yellow appearance turbidity and has a sharp fishy aroma typical of catfish with a semi solid texture. The appearance of crude catfish oil is in accordance with the results obtained from the research of Sembiring *et al.* (2018) and Ayu *et al.* (2019) which states that crude catfish oil has a brownish yellow color, smells fishy.

Table 1. Characteristic of physicochemical catfish oil, red palm oil, and shark liver oil.

Parameters	crude oil	refined oil	Red Palm Oil	Shark Liver oil	IFOS (2011)	SNI (2012)
Appearance	semi-solid	semi-solid	semi solid	Liquid		
Colour	cloudy yellow	bright yellow	orange	Light yellow		
Odor	fishy	a little fishy	-	Typical fish oil		
Free Fatty Acid (%)	2.45	1.33	1.44	0.62	≤ 1.5	≤ 1.3
AcidNumber(KOH/g)	4.87	2.63	2.87	1.24		
Peroxide Number (meq/kg)	8.77	4.39	9.56	20.05	≤ 3.75	≤ 10
Iod Number (g I ₂ /100 g)	83.94	87.65	89.20	181.32		
Saponification number (mg KOH/g)	172.17	192.90	170.82	91.75		
Carotene (mg/kg)			513.86			
Tocopherol (mg/kg)			925.80			

Table 2. profile of fatty acid catfish oil (crude dan refined), red palm oil, and shark liver oil.

Fatty acid	Crude catfish oil	Refining catfish oil	Red palm oil	Shark liver oil
C12:0 (laurat)	0.05	-	0.2	0.05
C14:0 (Meristat)	2.48	3.45	0.72	0.33
C16:0 (palmitat)	22.84	23.9	35.66	0.02
C18:0 (stearat)	4.41	5.36	3.15	14.47
C20:0 (arakidat)	0.24	-	0.25	2.49
C22:0 (Behenic)	0.09	-	0.04	-
C24:0 (Lignoceric)	0.13	-	-	0.22
□ Saturated fatty acid	30.11	32.71	40.02	17.84
C14:1 (meristoleat)	-	-	-	-
C16:1 (Palmitoleat)	0.7	-	0.12	0.19
C17:1 (cis-10-heptadecanoic)	0.04	-	-	-
C18:1 (Oleat)	34.97	36.5	38.16	24.47
C20:1 (Eicosanoat)	0.41	-	-	0.19
C21:0 (Heneicosanoic)	0.02	-	-	0.02
C24:1 (Mervanoat)	0.02	-	-	-
□ MUFA	36.16	36.5	38.28	24.47
C18:1n9t (elaidic)	0.05	-	9.07	0.08
C18:2 (linoleat)**	17.4	19.9	-	35.05
C18:3 (linolenat)*	0.72	1.72	-	3.40
C18:3 (gama-linolenat)**	0.32	-	-	0.20
C20:2 (Eikosadienat)**	0.38	-	0.04	0.03
C20:3 (eikosatrienat)*	0.51	-	-	-
C20:4 (Arakidonat)**	0.34	-	-	0.01
C20:5 (Eikosapentanoat)*	0.16	-	-	0.08
C22:2 (dekasadienat)**	-	-	-	-
C22:6 (Dokosaheksanoat)*	0.67	-	-	0.09
□ PUFA	20.55	21.62	9.11	38.94
Saturated Fatty Acid	30.11	32.71	40.02	17.84
Unsaturated Fatty Acid	56.71	58.12	47.39	63.81
Ω- 3*	2.06	1.72	0	3.56
Ω- 6**	18.44	19.9	0.04	35.35

The crude catfish oil was produced still contains impurity components that affect the color and odor of the oil. In order to improve the quality of the catfish oil to make it higher quality, these components must be removed or at least minimized through the refining process. The purification process includes blanching combined with heating and stirring. After refining, the refined oil of catfish has the appearance of a bright yellow oil (clearer than crude oil), but still has a slightly fishy aroma. The change in color and aroma is due to the absorbance of the bentonite and activated charcoal used. During the refining process, bentonite and activated charcoal are able to absorb color components and separate free fatty acids from fish oil. This result is consistent

with the statement of [Aji and Hidayat \(2010\)](#) that mixing bentonite and activated carbon can make the oil color clearer, eliminate unwanted odors, and extend the shelf life of oil. According to [Estiasih \(2009\)](#), the color and turbidity of oil is influenced by the content of free fatty acids, the amount and type of adsorbent used, temperature, and processing time.

Table 1, it had shown that the washing process can increase the saponification number and iodine in fish oil, but causes a decrease in free fatty acids, acid numbers and peroxide numbers. Decrease in the free fatty acid number of crude oils by 2.45% to 1.33% in refined oil, in accordance with the quality standards IFOS, namely $\leq 1.5\%$ with an acid number of crude oil of 4.87 mg KOH/g becomes 2.63 mg KOH/g

after purification. The decrease in the number of free fatty acids is due to the absorbance of bentonite and the added activated charcoal which can adsorb the non-glyceride components contained in free fatty acids (Sembiring *et al.*, 2018).

The peroxide value of crude catfish oil decreased after refining from 8.77 meq/kg to 4.39 meq/kg. The peroxide number does not meet IFOS standards, namely ≤ 3.75 meq/kg. The decrease in peroxide number occurs because the bentonite and activated charcoal used in the refining process can reduce the products of fatty oxidation such as peroxides, aldehydes and ketones in fish oil (Estiasih, 2009). The results of the peroxide analysis in this study were lower than the results of Julaikha (2014) study, namely 11.67 meq/kg for pure fish oil made from belly flap and higher than the results of the research by Kamini *et al.* (2016) who used the by-product of salai catfish processing, this was due to differences in the extraction temperature used.

The iodine number of catfish oil before and after being purified changes. After purification, catfish oil has a higher iodine number, which is 87.65 g I₂/100g than before purification, which is 83.94 g I₂/100g. This shows that pure catfish oil contains more unsaturated fatty acids than patin oil before it is purified. The iodine number indicates the presence of unsaturated fatty acids as a constituent of oil or fat. The amount of iodine bound by fatty acids indicates the number of double bonds contained in oil or fat (Harold, 1983).

The number of saponification increases after purification. Crude catfish oil has the saponification number value of 172.17 mg KOH/g after being refined to 192.90 mg KOH/g. The purification process shows that it can improve the quality of the catfish oil produced. The saponification number is the determination of the molecular weight of oil or fat, the longer the C chain, the greater the molecular weight of the fat and otherwise (Ketaren, 2005).

Characteristics of red palm oil

The results of the analysis of the characteristics of red palm oil are presented in Table 1. The results of the analysis show that the free fatty acid content, the acid number contained in red palm oil are 1.44% and 2.87 mg KOH/g. The free fatty acid was higher (1.44%) than the SNI standard ($\leq 1.3\%$) for red palm oil, namely $\leq 0.3\%$ and the peroxide number of 9.56 meq/kg is below the SNI red palm oil, which is ≤ 10 meq/kg. The iodine number in red palm oil was 89.20 g I₂/100 g. The presence of the iodine number indicates that there are unsaturated fatty acids as a constituent of red palm oil. The more iodine is bound by fatty acids, the more double bonds

contained in the oil. Red palm oil has a saponification number of 170.82 mg KOH/g. The large saponification number was indicated that red palm oil has shorter chain acids.

The carotene content in red palm oil is 513.86 mg/kg. The carotene content of red palm oil in this study was higher than that of Mas'ud (2007) and Riyadi (2009), respectively 390 and 375.33 mg/kg, but lower than the results of Widarta (2008) study of 564.07 mg/kg. The total tocopherol in red palm oil in this study was 925.80 mg/kg. The total carotene in the results of this study was slightly lower than that of Dauqan *et al.* (2011), which ranged from 953-955 mg/kg.

Characteristics of shark liver oil

The shark liver oil used is commercial shark liver oil. The results of the chemical characteristics of shark liver oil are presented in Table 1. The content of oil-free fatty acids can be used as an early indicator of oil damage. The formation of free fatty acids will accelerate the oxidative damage of oil because fatty acids are more easily oxidized when compared to their ester form. Shark liver oil contains 0.62% free fatty acids and has met IFOS standards, namely $\leq 1.5\%$, the acid number value is 1.24 mg KOH/g. The peroxide number in shark liver oil is 20.05 meq/kg. exceed IFOS standards. The high level of peroxide is because shark liver oil has undergone oxidation, this is presumably because during the storage process the oil is in direct contact with air and light for a long time. The oxidation of fat by oxygen occurs spontaneously if the fatty material is allowed to come into contact with air, while the speed of the oxidation process depends on the type of fat and storage conditions (Kamini *et al.*, 2016).

The iodine number in shark liver oil is 91.75 g I₂/100g. The iodine number indicates that there are unsaturated fatty acids as a constituent of shark oil. The amount of iodine bound by fatty acids indicates the number of double bonds contained in the oil (Harold, 1983). The iodine number shows the degree of saturation of the fatty acid components of shark oil. Oil with a high unsaturated fatty acid content will bind iodine in greater amounts and form saturated compounds (Ketaren, 2005).

The results of the analysis of shark liver oil was obtained a saponification number of 181.32 mg KOH/g. A large number of saponings indicates that shark liver oil has shorter chain fatty acids and a small number of soaping indicates a long chain of fatty acids. The long and the short chain fatty acids which is owned by a shark liver oil is very depending on the size of fat each fat molecule fish (Ahmad, 2014).

Fatty acid profile of catfish, red palm oil, and shark liver oil

The results of the analysis of the fatty acid composition of crude, pure, CPO, and shark liver oil were saturated fatty acid (SFA) with the highest CPO (40.02%), followed by pure and crude patin oil (32.71 and 30.11%) and lowest in shark liver oil (17.82%). The highest content of saturated fatty acids is palmitic except for the lowest shark liver oil. Shark liver oil is the highest type of fatty acid stearic acid.

Mono and poly-unsaturated fatty acids (MUFA and PUFA) were found in shark liver oil (63.81%), followed by pure catfish oil (58.12%) and crude fish oil (56.71%), and the lowest was in red palm oil (47.39%). The highest content of ω -3 and ω -6 fatty acids is in shark liver oil, and the lowest is in red palm oil. Catfish pure oil content of ω -3 and ω -6 is higher than the crude catfish oil (Table 2), and a crude contains ω -3 and ω -6.

MUFA and PUFA unsaturated fatty acids play a role in lowering blood pressure because unsaturated fatty acids function to reduce levels of Low Density Lipoprotein (LDL) cholesterol. According to Lichtenstein et al. (2006) and de Roos et al. (2001) state that MUFA are more effective at lowering blood cholesterol levels than PUFA, so that oleic acid is more often used for processed food formulations. Oleic acid (ω -9) is a fatty acid contained in MUFA which have more stable properties and have a better role than PUFA (Sartika, 2008). PUFA plays a role in lowering LDL cholesterol, and can reduce HDL, while MUFA can reduce K-LDL however, it can increase K-HDL. Artherosclerosis can be inhibited by decreasing the K-LDL K-HDL ratio (Muller et al., 2003).

The SFA content of shark liver oil in this study was 0.02% palmitate, 24.47% oleic, 0.08 EPA, and 0.09 DHA with Total SFA 17.84%, MUFA 24.47%, and PUFA 38.94%. The results of this study are different from the results of research by Rozi et al. (2016), showing that the fatty acids found in shark (*Charcharinus falciformis*) liver oil are 12.59% palmitic acid, 17.86% oleic acid, 1.50% EPA and 14.35% DHA with total SFA 18.59%, total MUFA 24.54 and total PUFA 19.11%. Other researchers reported that several deepsea fish species contained PUFA (4.11-99.63 mg/g), MUFA (66.17-467.22 mg/g) and SFA (13.11-486.55 mg/g) the dominant concentration of fatty acids, namely oleic and palmitic fatty acids (Suseno et al., 2010b).

Consumption of ω -3 such as EPA and DHA in the long term has been shown to have a positive impact on patients with coronary artery disease, which is able to reduce the risk of sudden death by

up to 45% compared to patients who do not consume EPA and DHA (Haris, 2004). EPA and DHA are also beneficial for healing keloid symptoms (Olaitan et al., 2011), reduce levels of Low Density Lipoprotein (LDL) cholesterol, anti-platelet aggregation, and anti-inflammatory (Haris, 2004).

Besides being useful for maintaining heart health, ω -3 is very important for the brain, retina and nervous tissue. Therefore the brain and retina are dependent on DHA supply. DHA is important for the development of the baby's nervous system in the third trimester of pregnancy, as well as in infancy and childhood. Therefore, pregnant women are advised to increase their intake of DHA and formula milk containing adequate amounts of DHA (Jacobsen, 2004).

Crude and pure catfish oil contains high ω -6 fatty acids, but is still lower than shark liver oil (Table 1). There is a difference in the dominant fatty acid composition of each oil due to the different living habitats of the fish and the food consumed by each fish. The composition and content of fatty acids of each species will vary, influenced by several factors such as season, temperature, growing place, fish species, age, sex, and eating habits.

Red palm oil (RPO) cannot act as a source of ω -3 and ω -6 fatty acids, the results of the analysis show that the acid content is not detected. However, RPO can act as a source of carotene and tocopherol, so RPO has potential as a functional food. The results of the analysis showed that RPO had carotene levels of 513.86 mg/kg and total tocopherols of 925.80 mg/kg (Table 1).

Carotenoids give palm oil a characteristic orange to red color. Carotenoids, especially α -carotene and β -carotene are precursors of vitamin A in the body. Provitamin A is equivalent to 2 vitamins A and has 100% activity as vitamin A. RPO can be used to treat vitamin A deficiency because of its β -carotene content. In addition, it is also useful for preventing coronary heart disease and cancer, as well as replacing cells that have been damaged (Sumarna, 2014).

Tocopherols are a group of vitamin E derived from plants. One type of active tocopherol that can be absorbed by the human body is α -tocopherol. Tocopherol is the most common form of vitamin E in the circulatory system (Ball, 2006). Vitamin E can function as an antioxidant so that it can prevent various degenerative diseases. As an antioxidant, vitamin E plays a role in the regulation of cellular signals, cell proliferation, gene expression, and triggers lipid peroxyl radicals by donating hydrogen atoms to Reactive Oxygen Species (ROS) (Devaraj et al., 2007).

In this research, catfish oil, shark liver oil and red palm oil were proven to contain unsaturated fatty acid like ω -3 (DHA and EPA) and ω -6 in fish oil (catfish and shark liver oil) as well as cathorene and tocopherol content in red palm oil. These three oils can be good prospects for the future as functional food products, one of which is packaged in capsule form as a health supplement.

Conclusion

Based on the results of the analysis, it can be concluded that catfish liver oil, shark liver, and red palm oil was contained unsaturated fatty acids MUFA and PUFA). PUFA and MUFA in crude catfish oil, pure catfish oil, shark liver oil, and red palm oils were 56.71, 58.12, 63.81 and 47.39% respectively. The highest composition Ω 3 and Ω 6 in shark liver oil was 3.5 and 35.5 followed by catfish oil 1.72 and 19.9%, respectively, while RPO did not have it. The content of EPA and DHA in shark liver oil was 0.08, 0.09. Red palm oil has a carotene content of 513.86 mg/kg and a total tocopherol of 925.80. Composition of nutrient from catfish oil, red palm oil, and shark liver oil have the potential to be used as functional foods.

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